

IR PROPERTIES OF GALACTIC CIRRUS NEAR THE POLAR CAPS

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ABSTRACT

We present a systematic study of the infrared properties of the high galactic latitude sky, by examining two large sections of the IRAS Sky Survey, which cover galactic latitudes from $b = 20$ to $b = 90$, and $b = -20$ to $b = -90$, at a reduced resolution of $7.5'$ / pixel. The *IRAS Sky Survey Atlas* (ISSA) plates are used to determine the variations in colors $R(12,25)$, $R(25,60)$ and $1\{(60,100)\}$ of clouds with spatial scales of 1-5 degrees, as a function of galactic latitude, and also as a function of the brightness of the emitting material.

Our results use the improved sensitivity provided by the ISSA plates, to present images highlighting distinct clouds with atypical colors. The cirrus appears to consist of a mixture with typical colors at lower galactic latitudes, and several cirrus wisps with anomalous colors near the galactic poles. We also report colors of cometary nebulae seen near the Southern galactic pole which have values of $1/(25,60) > 0.45$. The colors of the high galactic latitude cirrus is comparable to weakly illuminated cirrus at the edges of M31 and in other galaxies (Xu and Helou 1993; Helou, 1986).

INTRODUCTION

Since the discovery of the IR cirrus, a number of authors have improved upon our understanding of the diffuse IR emission from the galaxy. Boulanger and Perault (1988) documented the average colors of galactic cirrus, the $11/1100\mu$ emission ratio, and the variation of IR emission intensity throughout the high galactic latitude regions. They also reported the reduced emission at the polar caps which was apparent from about $b = 70$ to $b = 80$, which appeared to be the darkest patch in the IR sky. Desert, et al (1990) provided improved knowledge of the variations in color ratios for different regions in the galaxy, by relating them to variations in the relative abundance of three components: large grains, small grains and PAH's, with additional variations in ISRF. Recently, Helou (1986) and Xu and Helou (1993) have documented 11 color variations in the galaxies M31 and M33, which appear to arise from regions in the galaxies with low levels of illumination, and a deficiency of large grains.

From the recently released Infrared Sky Survey Atlas (ISSA) a new oppor-

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tunity has arisen to reexamine the IR colors of the interstellar medium with the improved sensitivity and resolution of the ISSA. We report the first result of an examination of the properties of clouds with sizes of a few degrees, near the weakly emitting polar caps of the galaxy.

1) ATA AND 2) ATA ANALYSIS TECHNIQUES

100 plates of 12x12 degree size were examined to determine the IR emission characteristics of the weakly emitting polar regions. The plates were selected to sample sightlines at high ecliptic and galactic latitudes. Each plate was block averaged by a factor of 5 in both dimensions, to a reduced spatial resolution of 7', in order to improve the S/N for weakly emitting clouds. A background subtraction algorithm was next applied to each plate separately, and then the plates were mosaiced into 2 large images which were analyzed for color variations. The emission brightness from the polar regions were much weaker than the average emission from galactic cirrus, such as those reported in Boulanger and Perault (1988), with 100μ intensities mostly in the range of $0.1 < I(100\mu) < 1 \text{ MJy Sr}^{-1}$, as opposed to typical cirrus for which $0.5 < I(100\mu) < 5 \text{ MJy Sr}^{-1}$. The locations of the plates selected for the our study are presented in Figure 1a, which shows an Aitoff projection in galactic coordinates and the locations of the selected plates.

Background Subtraction of the ISSA Plates

The ISSA plates are excellently suited for detecting the variations in IR emission on spatial scales of a few degrees. However, uncertain zodiacal background residuals do exist in all of the plates, which are a major obstacle in determining the actual emission from the regions studied. Since the backgrounds are a numerical residual, their spatial and spectral properties are not correlated in any consistent way with the original zodiacal background.

To address the problem of background removal, each plate was processed using newly developed routines which iteratively fit a planar background to the image, and subtract this background. The routine selects background points based on a consideration of the statistics of the image: points are labelled as background if they are within the range of the 0 to P percentile, and next the threshold P is increased until a set of points is derived which covers 3 out of 4 quadrants of the plate, with at least 2% of the background points coming from the least populated quadrant. The final value of P is typically around 5%, and varies with the covering fraction of IR-emitting material in the selected plate. A plane is then fit to the background points and subtracted from the plate. This process is repeated until each new iteration results in a residual at the edge of the plate of $R < 0.08$ for the 100μ images, and $R < 0.02$ for the other three bands.

The result is a uniform and repeatable background subtraction for the images. After background subtraction, histograms of the pixel intensities are examined for any remaining systematic offsets in either axis of the images. Figure 1b presents intensity histograms of the background subtracted images for the North Galactic Pole sample.

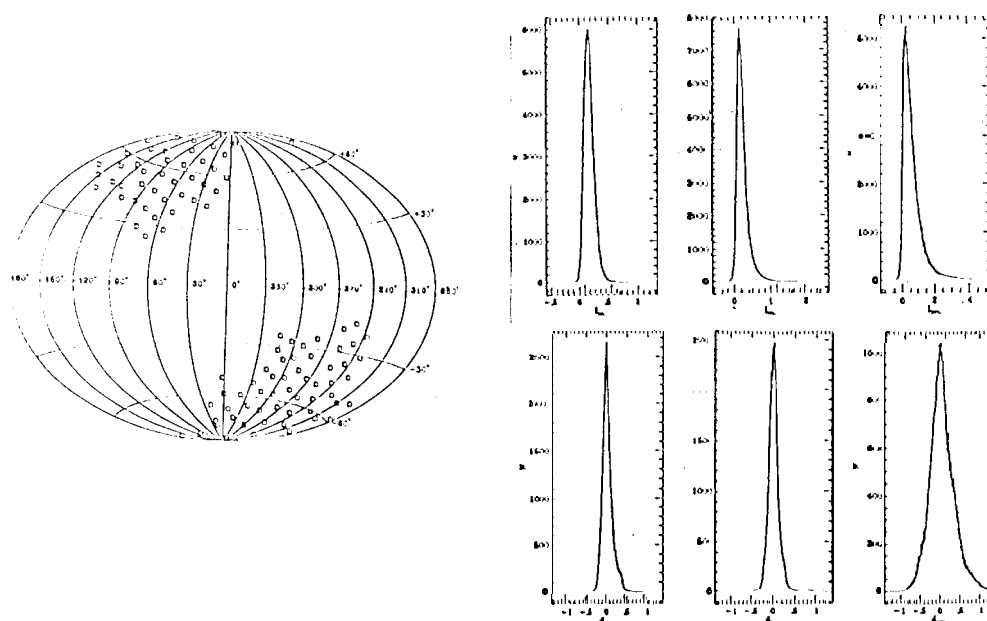


FIGURE 1 a.(left) Aitoff projection showing locations of plates used in study. b.(upper right) Histograms of pixel intensities for North Galactic Pole Region, at wavelengths (from left) 12μ , 60μ and 100μ . c.(lower right) Histograms of differences in overlap regions (see text).

Measuring the Accuracy of Background Subtraction

One estimate of the uncertainties from the background subtraction may be obtained by measuring the width of the negative going tail in the histograms of Figure 1 b, which for a correctly flattened plate will reflect only the instrumental noise of the IRAS survey, and will be free from systematic effects.

An independent assessment of the quality of background removal may be obtained by considering the difference in pixel values for overlapping regions of neighboring plates. The overlap is largest near the north and south celestial poles, where it is as much as 40% of the plate pixels, and then decreases steadily at lower declinations to about 2% at the celestial equator. Each plate from the two groups was background subtracted, and the average value and variance of the difference values for the overlap pixels was evaluated. Histograms of the differences in the overlapping pixels are presented in Figure 1 c for the North Galactic Pole sample. Gaussians were fit to the curves of Figures 1b and 1c and from both techniques we observe that the background uncertainties are on the order of 0.1 MJy Sr^{-1} for the 12μ and 60μ plates, and 0.25 for the 100μ plates.

RESULTS

An image of the background subtracted mosaic for the Northern Galactic Pole is shown in Figure 2a. From the figure, it is apparent that a number of structures with widely varying size scales exist in this region, suggesting different regimes of the ISM and/or different distances to the clouds. Visible at upper left in the image is the Draco cloud, and on the right is the Ursa Major molecular clouds,

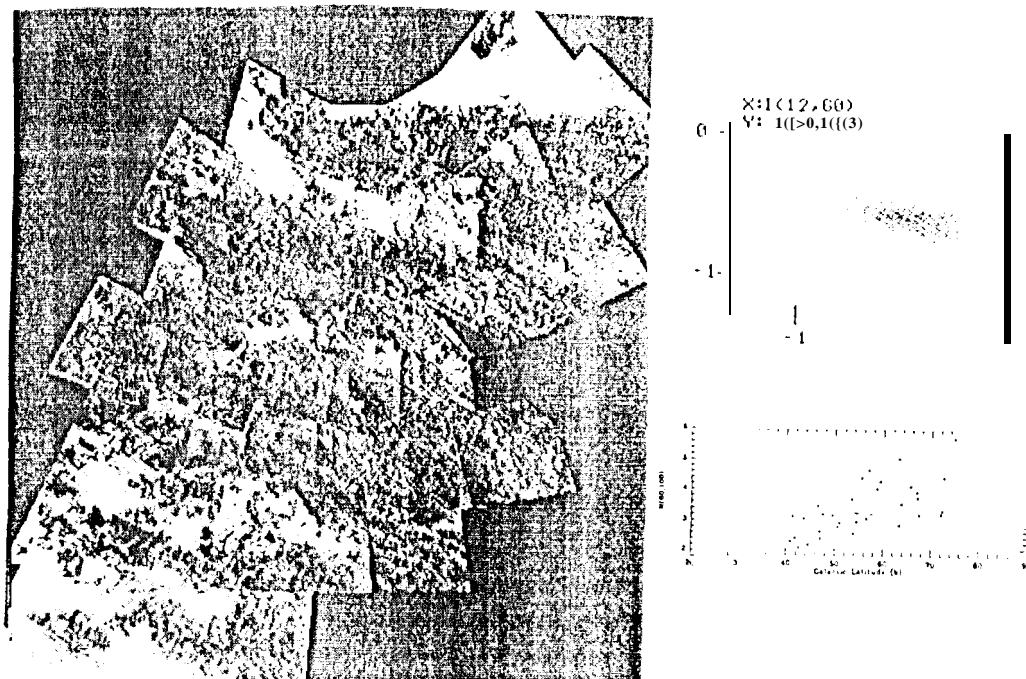


FIGURE 1. a. (left) 100μ mosaic for North Galactic Pole Region, showing anomalous wisp in center. b. (upper right) Color-color plot for same region; X axis: $\log[R(12,60)]$, Y axis: $\log[R(60,100)]$ c. (lower right) Plot of $1\{(60,100)\}$ vs. galactic latitude.

and part of the 'North Polar Spur'. The wisp at the center of the image was observed to have larger $1\{(60,100)\}$ than clouds at the edges, and a general trend of increasing $1\{(60,100)\}$ was observed as a function of galactic latitude for the Northern hemisphere. Figure 2b presents color-color diagrams for the Northern hemisphere mosaic, and Figure 2c shows the trend of increasing $R(60,100)$ as a function of galactic latitude. An additional result was the observation that the color $1\{(275,60)\}$ for the cometary clouds near the Southern galactic pole is anomalously large, with $1\{(60,100)\} > 0.4$.

Further studies are underway to determine possible causes of the anomalous colors seen in the ISSA plates, including difference in the grain populations due to shocks and other disruptive processes, variations in the ISRF, and effects of $|z|$ on the IRAS colors.

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